### The new era in helioseismology

*D.O. Gough*
*Institute of Astronomy, Madingley Road, Cambridge, U.K.*

The end of the millennium marks the beginning of the third phase of helioseismology. The first phase was the establishment of the initial astronomical inferences, such as estimates of the depth of the solar convection zone and the protosolar helium abundance obtained by comparing the seismic properties of theoretical solar models with the first wave of helioseismic data acquired using instruments that had not been designed for the purpose. The second phase was the determination of the spherically symmetric component of the hydrostatic stratification throughout most of the solar interior, and the angular velocity, using inverse methods to analyse the frequencies of normal modes estimated from data obtained most recently from purpose-built networks of ground-based observatories and from space. We have reached the point beyond which further pursuit of the now-well-tried methods to improve the inferences will be apparently slow. The next era will be characterized by painstaking attention to detail, to extract a new level of precision necessary to isolate subtle properties of the Sun for asking more sophisticated questions. We are already seeing the normal-mode representation of helioseismic waves being complemented by other representations that may be more suitable for investigating inhomogeneity and time variability particularly of the Sun's surface layers. The outcome will enable us to address more accurately issues concerning global dynamics, the equation of state and the chemical composition, and also the properties of convection and the seat of solar activity.

### A new class of solar oscillation measurements

*J. Schou*
*Stanford University, USA*

Over the last few years the quality and quantity of basic helioseismic data have increased dramatically as instruments such as MDI on the SOHO spacecraft and the GONG network have become operational. While the data from these new instruments have led to a significant increase in our ability to make inferences about the solar interior, it has become apparent that the current analysis techniques are limiting our ability to fully utilize these data. The high signal to noise ratio of these data means that subtle details of the spectra, which were ignored in earlier analysis, have to be properly modeled, both to extract all the available information and to eliminate systematic errors. These details include both solar effects and instrumental limitations and artifacts. In this talk I will describe some recent results, some of the problems involved in the analysis of normal modes and what progress we may be able to make once we understand these problems better.

### Recent Progress in Solar Interior Modelling

*Sylvaine Turck-Chieze*
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Acoustic modes are a suitable probe to check the internal solar composition and give constraints on regions of turbulence or mixing in stellar interiors.

The satellite SOHO has measured the most significant acoustic modes including low degree low order modes which are less dependent on the solar surface effects. Consequently the resulting accuracy on the sound speed profile from the core to the surface has been largely improved along the four years of the SOHO mission. The recent results allow us to check theoretical assumptions of solar modelling.

If turbulence is favoured to explain lithium burning in the tachocline layers located at the base of the convection zone, central mixing seems to be definitively rejected by the present observations. Nuclear reaction rates are also indirectly constrained through the behaviour of the sound speed. So, some puzzling problems on maxwellian distribution or dynamical effects in stellar plasma are enlightened by the accuracy of the present seismic data and the theoretical neutrino emissions partly checked.

We begin to have nowadays a dynamical vision of the half external part of the Sun, thanks to the adding density and rotation profile. Gravity modes will be extremely useful to improve the spatial resolution in the radiative region.

### Interior solar-cycle changes detected by helioseismology

*R. Howe et al.*
*National Solar Observatory, U.S.A*

Helioseismic measurements with the MDI instrument aboard SOHO, and complementary measurements from the GONG network, are revealing changes deep within the Sun as the solar cycle progresses. We will present results based on recent data from both experiments, including variations in the rotation rate deep inside the convection zone.

(Co-authors *J. Christensen-Dalsgaard, F. Hill, R.W. Komm, R.M. Larsen, J.Schou, M.J. Thompson & J. Toomre*).

### Solar metal abundance inferred from helioseismology

*M. Takata et al.*
*University of Cambridge, U.K.*

CO-AUTHOR: H. Shibahashi (University of Tokyo, Japan)

In the previous work, we constructed a solar model called the seismic solar model, which has the consistent profiles of the sound speed and the density as well as the consistent depth of the convection zone with helioseismology. The profile of the heavy element abundance, however, had to be parametrized for feasibility. Here we try to constrain the profile of the heavy element abundance as well by adopting the basic equations governing the solar structure.

### Solar models with metal-enhanced convective envelope

*J.Y. Yang et al.*
*Yunnan Observatory, China*

Previous low-Z models, aiming at decreasing solar neutrino fluxes, usually employ unreliable low central heavy element abundance and do not satisfy the helioseismic constraints. However, many evidences show that in the early stage of evolution of the solar system the sun was surrounded by dense molecular cloud and might accrete a considerable amount of matter to enrich the heavy element abundance in the envelope. We investigate the effects of moderate heavy elements enhancement in solar convective envelope on the solar structure and p-mode oscillations properties. The results show that except for smaller neutrino fluxes than those of the standard model already found before, the metal-enhanced models are able to reproduce the surface helium abundance and depth of the convection zone that have been determined by seismic inversion. The p-mode frequencies of the metal-enriched models are higher than those of the standard model, and are in better agreement with the observations.

Co-authors: *J.Y. Yang, Y. Li & H.Y. Xu*

### Recent Progress in Asteroseismology

*Jørgen Christensen-Dalsgaard*
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Asteroseismology, the study of stellar interiors on the basis of observations of multi-mode stellar oscillations, extends over a large part of the Hertzsprung-Russell diagram. Extensive observational results have been obtained for $\delta$ Scuti stars, although the lack of reliable mode identifications has so far precluded the use of the data for detailed investigations. The recently discovered EC14026 stars (or pulsating subdwarf B stars) promise information about the properties of stars on the horizontal branch. Solar-like oscillations, i.e., oscillations excited stochastically by convection, have been tentatively identified in a few cases, including through observations from the WIRE satellite. Promising cases are giant stars, where the expected amplitudes may make ground-based observations of the oscillations relatively straightforward. Major advances can be expected from the upcoming asteroseismic space projects under development or study; the most ambitious of the latter is the Eddington mission, recently proposed to ESA and up for selection later this year.

### Convective overshooting: a possible means to drive g-mode oscillations in $\gamma$ Dor variables

*Y. Li*
*Yunnan Observatory, China*

With increasing observation data in the past decade, the $\gamma$ Dor stars now define a new group of pulsating variables, occupying a clear region on the HR diagram that partly superimposed with the instability strip of the $\delta$ Scuti stars. However their periods, much longer than that of the $\delta$ Scuti stars, reveal that they are g-mode oscillators, and how these g-modes can be excited is still a debating subject. We investigate the possibility that overshooting from the boundaries of convection zone may excite g-mode oscillations. By studying a series of stellar models we found that overshooting cells move by frequencies in rough agreement with that of the observed oscillations, and $1.6M_{\odot}$ is the lower mass limit for a star to allow the stochastically excited oscillations penetrating out on the stellar surface as the observed oscillations.

### Solar Irradiance Variability

*J. Lean*
*Naval Research Laboratory*

Solar irradiance varies at all wavelengths and on all time scales measured thus far. Space observations of the Sun during the past two decades have observed total, UV spectral and X-ray irradiance with sufficient precision to characterize 27-day rotations and the 11-year solar cycle. Magnetic features (dark sunspots, bright faculae, hot coronal loops) are known to be primary sources of irradiance variability. Models of active regions and network in the solar atmosphere successfully replicate much of the observed irradiance variability during the contemporary epoch and provide, as well, estimates of spectrum changes at visible, infrared and extreme ultraviolet wavelengths where the observations are sparse. A model of total irradiance based on sunspot darkening and facular brightening accounts for a significant fraction (88%) of variance in a composite observational record from 1978 to 1996. But in the ascending phase of cycle 23 discrepancies in annual trends between the model and measurements, and among the measurements themselves, exceed 100 ppm. Irradiance changes on centennial time scales are speculated to exceed solar cycle amplitudes, consistent with indirect terrestrial proxies of solar activity (cosmogenic isotopes and geomagnetism) and the range of variations in Sun-like stars but actual physical connections between terrestrial proxies and irradiance remain to be quantified. Various historical reconstructions based on different assumptions about long-term irradiance trends differ from each other, and also in their ability to replicate the observational record in recent decades.

### Spectral irradiance variations

*Sami K. Solanki*
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Not just the total solar irradiance is known to vary, but also the solar spectrum. Observations and models of solar spectral irradiance variations are presented.

**Stellar Irradiance Variations**

*Richard R. Radick*
*Air Force Research Laboratory, Sunspot, NM, USA*

The variability of several stars similar to the Sun in mass, age, and average activity has been monitored regularly in chromospheric Ca II HK emission for over three decades, and photometrically for over fifteen years. Larger samples have been observed less comprehensively. Analogous solar time series exist. A comparison of solar variability with its stellar analogs indicates that the Sun's current behavior is not unusual among sunlike stars, although some observations suggest that the amplitude of the Sun's cyclic variation, measured photometrically, may be smaller than for other sunlike stars. The stellar measurements imply that a true luminosity variation underlies the cyclic irradiance changes. The amplitude discrepancy remains a vexing problem, although an irradiance effect arising from viewing geometry may account for part of it.

**Turbulent Convection and Differential Rotation Within the Sun**

*J. Toomre et al.*
*JILA, University of Colorado, Boulder, USA*

Differential rotation and cycles of magnetic activity are intimately linked dynamical processes within the deep shell of highly turbulent convection occupying the outer 200 Mm below the solar surface. Helioseismology has shown that the angular velocity $\Omega$ within the solar convection zone involves strong shear layers both near the surface and especially at its base near the interface with the radiative interior. The tachocline of radial shear there that varies with latitude is thought to be the site of the global magnetic dynamo. Most recent continuous helioseismic probing with MDI on SOHO and from GONG have revealed systematic temporal changes in $\Omega$ with the advancing solar cycle. These include propagating bands of zonal flow speedup extending from the surface to a depth of about 70 Mm, distinctive out-of-phase vacillations in $\Omega$ above and below the tachocline with a period of about 1.3 years near the equator, a changing pattern of meridional circulation cells with broken symmetries in the two hemispheres, and complex speedups and slowdowns in the bulk of the convection zone. We review these helioseismic findings and their implications. We also describe current 3–D numerical simulations of anelastic rotating convection in full spherical shells used to study the differential rotation that can be established by such turbulence exhibiting coherent structures. These simulations enabled by massively parallel computers are making promising contact with aspects of the $\Omega$ profiles deduced from helioseismology, but challenges remain.

**The solar and astrophysical dynamos**

*A. Brandenburg*
*University of Newcastle, U.K.; and*
*NORDITA, Copenhagen, Denmark*

There are a number of fundamental uncertainties in our understanding of the solar dynamo. What is the significance of the lower overshoot layer, does the dynamo work in the entire convection zone, why is the field oscillatory, migratory, and dipole-like? Although some of those properties can be understood in the framework of $\alpha - \Omega$ dynamo theory, there are some basic questions whether this theory can actually work. In my talk I will present a model of helically forced turbulence that allows us to address the question what generates the large scale field (e.g. $\alpha$-effect and/or inverse cascade). Next, a simulation of a convective dynamo with shear will be presented, where a large scale magnetic field is found to develop near the lower overshoot layer. Finally, comparisons will be made with dynamo action in galaxies and accretion discs. In all cases the effects of noise are rather strong, and it is the presence of large scale shear which is crucial in producing a well-defined large scale field. The importance of magnetic instabilities will be highlighted in connection with stellar dynamos, where the observed cycle periods point toward the existence of different branches of activity.

**Vorticity, current helicity and alpha-effect for magnetic-driven turbulence in the solar convection zone**

*Günther Rüdiger*
*AIP, An der Sternwarte 16, D-14482 Potsdam, Germany*

The turbulent electromotive force as well as the kinetic and current helicities have been computed for a turbulence subject to magnetic buoyancy and global rotation. The field dynamo-alpha is found as positive in the northern hemisphere and negative in the southern hemisphere and the kinetic helicity has just the same signs.

In agreement with the observations the current helicity is found as negative in the northern hemisphere and as positive in the southern hemisphere. Our current helicities and alpha-effects are thus always out of phase. The signs of alpha-effect and both helicities exactly correspond to a recent numerical simulation by Brandenburg & Schmitt.

Also the turbulent angular momentum transport has been computed which proves to be always inwards. We can thus explain why in the supergranulation zone deeper layers appear to rotate faster than the solar surface plasma, or why in the solar tachocline at high-latitudes the angular velocity decreases outwards. The dynamo number derived from the observed current helicity reveals it as positive and rather small with massive consequences for the dynamo in the solar convection zone.

**Transport and storage of magnetic flux by Penetrative turbulent compressible convection**

*S.M. Tobias et al.*
*University of Leeds, U.K.*

We present the results of a series of numerical experiments that investigate the pumping of magnetic fields by turbulent penetrative convection. This pumping mechanism, which is responsible for the transport of flux from the solar convection zone to the stable overshoot region, is believed to be a crucial component for the operation of a large-scale solar interface dynamo. The high-resolution three dimensional simulations show that efficient pumping occurs due to the action of strong coherent downwards plumes. The pumping depth is then calculated as a function of magnetic field strength, rotation rate, supercriticality and stiffness of the interface.

**New developments in Local Area Helioseismology**

*T.L. Duvall Jr.*
*NASA/Goddard Space Flight Center, USA*

Several techniques are used to study local areas in helioseismology, including time-distance helioseismology, acoustic imaging/holography, and ring diagram analysis. These techniques can be used to study flows, magnetic fields, and temperature inhomogeneities. The "local" area studied can be as small as a supergranule, or as large as the entire convection zone in the case of meridional circulation as studied by Giles and colleagues. Active regions have been studied with some interesting results, with complicated flow patterns below sunspots and detectable sound speed inhomogeneitities in the 10 Mm below the spots.

Another interesting result is the detection of sunspots on the back side of the Sun by Lindsey and Braun using the holography technique. A confirmation of their result using the time-distance technique will be discussed.

**Seismic Holography of the Solar Interior and Far Side**

*D.C. Braun et al.*
*Solar Phys. Res. Corp. & Colorado Res. Assoc., U.S.A.*

The development of solar acoustic holography has opened a major new diagnostic avenue in local helioseismology. Its application to SOI-MDI data from *SOHO* has revealed "acoustic moats" surrounding sunspots, "acoustic glories" surrounding complex active-regions, and "acoustic condensations" suggesting the existence of significant seismic anomalies up to 20 Mm beneath active-region photospheres. It has given us the first seismic images of a solar flare, and has uncovered a remarkable anomaly in the statistical distribution of seismic emission from acoustic glories. Phase-sensitive seismic holography is now producing high-resolution maps of sound travel-time anomalies caused by magnetic forces in the immediate subphotosphere, apparent thermal enhancements in acoustic moats, and Doppler signatures of subsurface flows. It has also produced the first seismic images of active regions on the far-side of the Sun, giving us a powerful tool for forecasting more than a week in advance their arrival at the east limb. This diagnostic now promises a new insight into the hydromechanical and thermal environments of the solar interior in the local perspective.

Co-author: C. Lindsey, *SPRC*

**Wave Propagation in the Magnetised Solar Atmosphere**

*C.S. Rosenthal et al.*
*Institute of Theoretical Astrophysics, University of Oslo*

Co-Authors: Bogdan, T.J., Carlsson, M., Hansteen, V., McIntosh, S., Nordlund, Å., Stein, R.F.

We have simulated the propagation of magneto-acoustic disturbances through various magneto-hydrostatic structures constructed to mimic the solar magnetic field. As waves propagate from regions of strong to weak magnetic field and vice-versa different types of wave modes (transverse and longitudinal) are coupled. In closed-field geometries we see the trapping of wave energy within loop-like structures. In open-field regions we see wave energy preferentially focussed away from strong-field regions.

We discuss these oscillations in terms of various wave processes seen on the Sun - umbral oscillations, penumbral running waves, internetwork oscillations etc.

**Generation of the Solar Subsurface Shear**

*K.L. Chan*
*Hong Kong University of Science and Technology, China*

Helioseismology has shown that there are two shear layers in the angular velocity distribution of the sun. The principal one is the one between the bottom of the convection zone and the radiative interior. This layer manifests the transition from an almost uniform rotation in the interior to the substantial differential rotation of the convection zone. The second shear layer is right beneath the surface of the sun, where the angular velocity changes by a few percent over a distance of $\sim 5\% R_\odot$ .

We have recently made a parametric study of rotating convection using a large number of numerical experiments with different energy fluxes, rotation rates, and inclination of the rotation vector. Based on the results, we propose that the sharp change of angular velocity near the surface of the sun can be explained by the behavior of the rotating turbulence and the stratification (not by simple angular momentum conservation). This process is also compatible with a radially independent distribution of angular velocity in the deeper part of the convection zone. High-resolution calculations are used to illustrate the dynamics of the rotationally distorted turbulence and its roles in generating the angular velocity shear.

**New inferences of the Sun by high degree modes: the external layers and the equation of state**

*M.P. Di Mauro et al.*
*TAC, Theoretical Astrophysisics Center, Aarhus, DK*

We investigate the structure of the Sun by helioseismic inversion of a set of p-mode frequencies which include new accurate observations of modes with high degree ($l < 1000$) obtained from MDI instrument flying on board of SOHO satellite. The use of high-degree frequencies highly improves the resolution of the solar structure in the near-surface region, where effects of the equation of state are felt more strongly. In particular, we show the potential of such data to test the solar equation of state and to constrain the solar envelope helium abundance.

## The New Picture of Solar Magnetic Field Dynamics from TRACE

*Alan Title & Karel Schrijver et al.*
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The high cadence, high spatial resolution, and continuous observations by TRACE of the outer solar atmosphere are providing a new picture of coronal heating, dynamics and evolution. High resolution images in the 6,000 to 2,500,000 K temperature range of the filters immediately shows that the majority of the corona has a fine structure at or below the TRACE resolution of one arc second. Further, temperatures across the entire range coexist on similar spatial scales. The intensity structure and temporal evolution of the TRACE loops shows that they are heated within 20,000 km of the solar surface and that they can not be modeled as static features. Movies show that the upper atmosphere is constantly responding to evolution of the magnetic fields in the photosphere down to the smallest observable scales.

## Yohkoh Soft X-ray Observations in One Solar Activity Cycle

*H. Hara*
*National Atronomical Observatory, Japan*

We report coronal activities of the Sun in an 11-year solar activity cycle based upon *Yohkoh* soft X-ray observations. Active regions can be defined by an intensity threshold in X-ray histograms that are made from full-Sun X-ray images, and variabilities of active regions and regions outside active regions are investigated by analyzing the X-ray histograms. A shape of X-ray histogram is similar to that of the photospheric magnetic flux. This indicates a structural magnetic connectivity between the photosphere and corona. Both total X-ray intensity of active regions and total projected area of active regions change with the solar activity cycle, and the surface brightness of active region is roughly constant over the activity cycle. On the other hand, surface brightness of quiet-sun corona changes with the activity cycle in phase. Since a strong correlation between total X-ray intensity and total photospheric magnetic flux is also shown for quiet-sun regions, this clearly shows that the heating of quiet-sun corona is also closely associated with the presense of magnetic field. As a tiny magnetic activity in the solar corona, we report a statistical work on X-ray bright points (XBPs). Anti-correlation between the number of XBPs and the sunspot number has been confirmed, though a number of XBPs are found in quiet-sun regions of a low X-ray intensity at solar minimum. A deviation from a uniform latitudinal distribution and enhancement of the XBP number near the boundary of polar coronal holes are found during the course of this study.

## The Emergence of Magnetic Flux in Active Regions

*W.P. Abbett et al.*
*Space Sciences Lab, Univ. of California, Berkeley CA, USA.*

Over the past decade, "thin flux tube" models have proven successful in explaining many properties of active regions in terms of magnetic flux tube dynamics in the solar interior. Unfortunately, recent, more sophisticated two-dimensional MHD simulations of the emergence of magnetic flux have shown that many of the assumptions adopted in the thin flux tube approximation are invalid. For example, unless the flux tubes exhibit a large amount of initial field line twist — and observations of emerging active regions suggest they do not — they will fragment (break apart) before they are able to emerge through the surface.

We attempt to resolve this paradox using a number of 3-D MHD simulations (in the anelastic approximation) that describe the rise and fragmentation of twisted magnetic flux tubes. We find that the degree of fragmentation of an evolving Omega-loop depends strongly on the three-dimensional geometry of the tube — the greater the apex curvature, the lesser the degree of fragmentation for a fixed amount of initial twist. We also find that the Coriolis force plays a dynamically important role in the evolution and emergence of magnetic flux. We are able to infer general observational characteristics of the emerging flux, and compare our theoretical data with recent observations.

Co-authors: *G.H. Fisher, SSL, UC Berkeley, CA., USA, & Y. Fan, HAO, Boulder, CO., USA.*

## Development of structure in pores and sunspots: flows around axisymmetric magnetic flux tubes

*A.M. Rucklidge et al.*
*University of Cambridge, U.K.*

Flux elements, pores and sunspots form a family of magnetic features observed at the solar surface. As part of developing a fully nonlinear model of the structure of these features and of the dynamics of their interaction with solar convection, we (A.M. Rucklidge and N.E. Hurlburt) conduct numerical experiments on idealised flux tubes in a compressible convecting atmosphere in cylindrical boxes of radius up to eight times their depth. We find in axisymmetric geometry that the magnetic field strength of the flux tubes is roughly independent of both distance from the centre and the total flux content of the flux tube, but that the angle of inclination from the vertical of the field at the edge of the tube increases with flux content. In all our calculations, fluid motion converges on the flux tube at the surface. The results compare favourably with observations of pores; in contrast, large sunspots lie at the centre of an out-flowing moat cell. We conjecture that there is an inflow hidden beneath the penumbrae of large spots, and that this inflow is responsible for the remarkable longevity of such features. We also investigate how the non-axisymmetric instabilities of the flows around the flux tubes affect the structure within the flux tube.

## Spectroscopy of Active Stars and Stellar Prominences

*Andrew Collier Cameron*
*University of St Andrews, U.K.*

Over the dast decade or so, tomographic imaging of stellar surfaces and coronal structures has revealed a wealth of information concerning magnetic structures on a wide range of stellar types. Surface differential rotation measurements have been secured for several stars by tracking the rotation of starspots at different latitudes. Surface magnetic flux distributions can be mapped using Zeeman-Doppler imaging methods, and evidence of cyclic changes in surface field geometries is emerging. Extended systems of prominence-like condensations of neutral material have been observed in the coronae of many young, rapidly rotating solar-type stars. Evidence is also emerging that the lifetimes of individual spots and active regions may be greater in giants than in dwarfs.

I will review briefly the types of spatial information that can be obtained using these methods, and discuss how they can be combined to probe the three-dimensional geometries of stellar coronae. In particular, I'll discuss the evidence for large-scale dipolar field structures in young stars.

## One Solar Cycle of Yohkoh/HXT Flare Observations

*Taro Sakao*
*ISASA, Japan*

No abstract available.

**Soft X-ray Flares and Magnetic Configuration in Solar Active regions**

*Hongqi Zhang et al.*
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*National Astronomical Observatories*
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In this paper, we examine the observational soft X-ray flares and the relationship with photospheric vector magnetograms in solar active regions.

We analyze the initial reconnection of the magnetic field in the flares occurred near the magnetic neutral line in the lower atmosphere of active regions, where the highly sheared magnetic flux probably erupts up and triggers the reconnection of the large-scale magnetic field.

We also represent the corresponding relationship between the current helicity and soft X-ray flares in solar active regions.

**Chromospheric heating in the late gradual flare phase**

*A. Czaykowska et al.*
*MPI for extraterrestrial Physics, Garching, Germany*

Upflows of several tens of km/s have been observed by SOHO/CDS in the late gradual phase of the M6.8 two-ribbon flare on April 29, 1998. These upflows observed in EUV lines formed at coronal temperatures are interpreted as chromospheric evaporation which fills the post-flare loops with hot plasma. In order to achieve chromospheric evaporation, the chromospheric plasma has to be heated to coronal temperatures. The energy for this heating process is assumed to be provided by magnetic reconnection. The mechanism which transports the energy from the reconnection site to the chromosphere might be either thermal or non-thermal. We compare the observed upflow velocities with the velocities derived by different chromospheric heating models in order to decide which mechanism might account for the chromospheric heating. From non-thermal models we take the electron energy flux necessary to achieve the observed velocities and calculate the expected hard X-ray counts in Yohkoh/HXT for non-thermal thick-target Bremsstrahlung generated by this electron flux. This leads to the conclusion that high-energy ($> 15\,\mathrm{keV}$) non-thermal electrons are unlikely to be responsible for the chromospheric heating since a significant number of HXT counts are expected from the resulting electron energy flux but not observed. Recent thermal conduction models seem to be more appropriate for explaining the observations.

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**The Time Variable Solar Atmosphere**

*Olav Kjeldseth-Moe et al.*
*Institute of Theoretical Astrophysics, UiO, Norway*

We review and demonstrate the new dynamic and time variable picture of the solar transition region and corona particularly as observed by the Coronal Diagnostic Spectrometer, CDS, on SOHO, but also supplemented and supported by data from SUMER, EIT and TRACE. Time variable phenomena, such as sunspot flows and oscillations, "blinkers" and rotating transition region features ("tornadoes"), will be mentioned.

However, most of our attention will be on the time variable active region loops. Loops in the temperature range 1-5 $\times$ $10^5$ K, extending 20 000 - 90 000 km above the solar surface, are seen to appear and disappear in 10-30 minutes. Their variability extends to coronal temperatures, 1-3 MK, but is less prominent here than in the transition region. The time variability is combined with large Doppler shifts of the emission lines suggesting gas velocities in and near the loops of 20 km $s^{-1}$ to more than 100 km $s^{-1}$. The Doppler shifts varies, often between red and blue shifts, on the same time scale as the emission.

This remarkable activity goes on for extended periods of time as is exemplified by a 39 hour sequence of CDS raster images of active region loops at the solar limb. The observations challenges previous calculations of loop variability and dynamics as is pointed out in a brief comparison with models of time variable and dynamic loops. (With Terje Fredvik, ITA/UiO, Norway.)

**Mechanical Coupling from Photosphere to Corona**

*P. G. Judge et al.*
*Monash University, Australia*

We study the coupling between the solar photosphere and higher layers using coordinated timeseries observations that include measurements of photospheric magnetic and velocity fields, and thermal properties of higher layers. Coupled with simplified MHD models, co-aligned high resolution data from the SOHO and TRACE spacecraft allow us to follow the dynamics of the atmosphere systematically as a function of height from photosphere to corona. We will present results concerning the nature of the dominant wave motions in the quiet Sun's atmosphere. Comments will be made concerning the relative importance of wave reflection and the effects of variations in average magnetic flux on the inferred dynamics. An attempt will be made to clarify some apparent discrepancies concerning chromospheric dynamics that exist in the literature.

### MHD Seismology of the Solar Corona with SOHO and TRACE

*V.M. Nakariakov*
*University of Warwick, U.K.*

Recent discoveries of MHD wave motions in the solar corona (slow magnetoacoustic waves in polar plumes and long loops, oscillations of coronal loops, coronal Moreton waves) done with EUV imaging telescopes onboard SOHO and TRACE provide an observational basis for the MHD seismology of the corona. Measuring the properties of MHD waves and oscillations (periods, wavelengths, amplitudes, temporal and spatial signatures), combined with theoretical modelling of the wave phenomena, allow us to determine values of the mean parameters of the corona (the magnetic field strength, transport coefficients, etc.). As an example, we consider post-flare decaying oscillations of loops, observed with TRACE (14th July 1998 at 12:55 UT). An analysis of the oscillations shows that they are quasi-harmonic, with a period of about 265 s, and quickly decaying with the decay time of about 14.5 min. We interpret these oscillations as a standing kink global modes of the loops. The period of oscillations allows us to determine the Alfvén speed in the oscillating loop about 770 km/s. This value can be used for deduction of the value of the magnetic field in the loop (giving 15-25 G). The decay time, together with the assumption that the decay is caused by viscous (or resistive) dissipation, gives us the Reynolds number of $10^{5.3-6.1}$ (or the Lundquist number of $10^{5.0-5.8}$). Other possible means for the oscillation decay, such as wave leakage and linear and nonlinear wave coupling are estimated.

### Density, temperature and element abundance measurements

*H.E. Mason*
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The observations from SOHO have revolutionised our understanding of the Sun. In this review we explore the nature of the solar atmosphere with spectroscopic observations from CDS (Coronal Diagnostic Spectrometer) and SUMER (Solar Ultraviolet Measurement of Emitted Radiation). CDS and SUMER provide the opportunity to study solar features over a wide range of temperatures. Spectroscopic diagnostic techniques have been used to derive electron density and temperature distributions, together with elemental abundance measurements. These physical parameters constrain the solar models which have been developed to explain coronal heating and solar wind acceleration processes.

### Looking for the FIP Effect in EUV Spectra

*B.N. Dwivedi*[1,2], *E. Landi*[2] *and A. Mohan*[1]
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We present results from a study of extreme-ultraviolet (EUV) off-limb spectra obtained with the Solar Ultraviolet Measurements of Emitted Radiation (SUMER) on the spacecraft SOHO. Using EUV line intensities, we deduce plasma temperatures and densities in the off-limb solar plasma. We make use of this information to study the FIP effect in the solar corona. We have looked for FIP effect in EUV spectra obtained by SUMER in a considerable detail. In particular, we report K/Ar, Si/Ar and S/Ar relative element abundances and investigate the height dependence of the FIP bias in the solar corona. Also, we study the relative Mg/Ne abundance in an active region at the solar limb to investigate the correlation of the FIP bias with magnetic loop structures in the field of view.

### Transition Region Blinkers, X-ray Bright Points and Nanoflares

*C.E. Parnell et al.*
*University of St Andrews,U.K.*

Blinkers are small bright emission events observed best in the O V transition region line that occur above the supergranular network. They were first observed using SoHO/CDS data and were identified manually by Harrison (1997). They are believed to be density enhancements, but how they are created and what their properties are is not well known.

We have developed the first program to automatically identify blinkers and their characteristics. The evolution of the magnetic field observed by SoHO/MDI below these blinkers has then be analysed to determine what magnetic field configuration is required for a blinker to occur. Also, the coronal emission above has been investigated using SoHO/CDS and TRACE data to determine the relation between blinkers, x-ray bright points and nanoflares. All three of these events are known to occur at the network, but as yet the relation between them is not understood.

Putting together the results from these multi-wave length studies we have been able to determine a model for how blinkers occur and what their effect is on the transition region around and the corona above.

Co-authors: D. Bewsher/St Andrews, R.A. Harrison/RAL, and A.W. Hood/St Andrews

### Coronal Mass Ejections Observed with LASCO and EIT

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A set of 32 coronal mass ejections observed with the LASCO and EIT instruments on SOHO have been examined. These events have been selected from the period between May 1997 through May 1998 and includes the period of solar minimum and the rise of solar cycle 23. The criteria for including these events were that they were observed as a CME in LASCO, they were well observed with EIT and they were located near disk center. The sources of these 32 events were active regions without filaments (26 cases),active regions with filaments (7 cases) and quiescent filaments (6 cases). In the EIT, the signature of the initiation of the coronal mass ejection includes flares, EIT waves, coronal dimmings and mass ejections. The characteristics of the photospheric magnetic activity associated with these events, observed with NSO/Kitt Peak and MDI/SOHO magnetograms, indicate that CMEs are associated with a wide range of activity that includes small scale flux emergence and cancellation, large scale flux emergence, and large scale flux decay. During this period of the solar cycle, the solar disk contains few active regions which are generally generally short lives so that there may be a solar cycle dependence to these conclusions. (Co-author: P. Subramanian, George Mason Univ. and NRL)

### Flare and CME onset: UV spectra show fast 3-D flow

*D.E. Innes et al.*
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We present observations taken in the corona above a flare that occurred on the west limb of the Sun. SUMER spectra show large red (400 km/s) and blue (700 km/s) Dopplershifts in Fe XX ($10^7$ K), Cr XVI ($5 \times 10^6$ K), Si IX ($10^6$ K) and O III ($10^5$ K) emission lines. These shifts are associated with a fast moving (500 km/s) optical emission front detected in high cadence images, taken with the coronagraph MICA. Yohkoh images, taken 8 min after the hard X-ray peak, show fast soft X-ray ejecta that can be extrapolated back to the position of pre-flare coronal arcade structure seen in EIT 195 images. The observations are interpreted as evidence of a blast wave propagating through the active region coronal loop structure very early in the flare evolution.

Co-authors: *W. Curdt, G. Stenborg, R. Schwenn & D.E. McKenzie*

## Ultraviolet Spectroscopy versus White Light observations of Coronal Mass Ejections

*A. Ciaravella et al.*
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The UltraViolet Coronagraph Spectrometer observed several tens of CMEs providing new insights into the classical white light scenario. Temperature, density, abundances, ionization stage, velocity along the line of sight can be determined. On the other side, the different perspectives provided by images in the UVCS spectral lines and LASCO white light can reveal the three dimensional velocity structure of a CME and constrain the magnetic topology.

Moreover, the UVCS observations, higher in the corona ($\geq$ 1.5 Rsun), can be also compared to the early stage of a CME, detected by EIT, to investigate the temporal evolution of the ejected plasma and put constraints on the heating rate required to match the physical conditions obtained from the UVCS spectra.

We present a CME observed on Feb 12, 2000 by UVCS and LASCO along with the preliminary results of the analysis.

## Observations and Models of the Fast and Slow Solar Wind

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There are two major types of solar wind. The steady fast wind originates on open magnetic field lines in coronal holes, which may last for many solar rotations. In contrast, the unsteady slow wind is coming from the bulk or boundary layer of streamers, which are mostly magnetically closed and open up only temporarily. Many observations of the solar wind have in the past been made, e.g., in situ by Helios and Ulysses and remotely by SOHO. Correspondingly, many models for the fast and slow wind have been developed to different levels of sophistication. The majority of the models is concerned with the fast wind. Essential properties of fast streams can be reproduced by 1-D multi-fluid models involving broad-band waves. Yet, the integration of the fluid equations must start low in the corona in the magnetic funnels at transition region level. Also, 3-D MHD models have recently been developed. Owing to its time-variable nature, no robust understanding of the slow wind exist. Apparently, its acceleration starts only beyond two solar radii. Key empirical constraints, which are imposed on the models by the Helios (near-Sun, in-ecliptic) and Ulysses (high-latitude) interplanetary measurements and by the SOHO plasma-spectroscopy results, are discussed with respect to the fluid as well as kinetic properties of the wind. Selected results from modelling and observations are presented and discussed.

## Observations and models of coronal heating

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The theoretical basis and observational evidence for possible scenarios of coronal heating are reviewed, with particular emphasis on the interpretative uncertainties involved in the detection of low energy bursts, or nanoflares. From a theoretical point of view, it appears that the presence of complex topologies in the coronal magnetic field is crucial both both for the triggering of discrete small-scale events and efficient wave dissipation. At low energies, the distinction between AC/DC heating may be blurred, since the power output from dissipating waves or small scale current sheets can be bursty and intermittent. The interplay of these phenomena is discussed within the unifying framework of MHD turbulence, and the importance of progress in forward modelling from theories to observables in the understanding of sub-resolution physics is underlined.

## Coronal Heating by Nano-flares and MHD Waves: Results from SOHO and Solar Eclipses

*K. J. H. Phillips et al.*
*CLRC Rutherford Appleton Laboratory, U.K.*

We report on observational evidence for the rôles that small flare-like events and short-period MHD waves play in the heating of the solar corona. In several studies of SOHO and Yohkoh data, we examine the numbers and energies of small events in the EUV and in soft X-rays can account for the necessary energetics of the quiet-Sun corona, finding that EUV events at least might be sufficient to provide the heating, at least in closed-field regions. Results will be summarized in this paper. However, MHD waves may still play an important part, and in a separate investigation we have used fast-cadence imaging of the white-light and green-line corona during the total eclipse of 1999 August 11 to search for short-period modulations. The imaging system is the Solar Eclipse Coronal Imaging System (SECIS), and consists of a pair of CCD cameras and an adapted PC to form images of the corona at a frame rate of 44 $s^{-1}$. Preliminary analysis of the data suggests the presence of fast changes over the 2-minute-long period of eclipse totality. This paper will also report on the SECIS data.

## Heating the Quiet Corona by Nanoflares: Evidence and Problems

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The content of coronal material in the quiet Sun is not constant as soft X-ray and high-temperature EUV line observations have shown. New material, probably heated and evaporated from the chromosphere is occasionaly injected even in the faintest parts above the magnetic network cell interiors.

We discuss the characteristics of the largest of these events, based on simultaneous transition region observations (in EUV and radio) and the observed analogies to flares. Assuming that the smaller events follow the same pattern, we estimate the total energy input. Various recent analyses are compared and briefly discussed. Finally we present the results of a simulation, extrapolating the observed range of microflares to smaller energies. The simultation indicates that the extrapolation to smaller events is problematic and that smaller events may play an even more decisive role than previously assumed. The hypothesis of nanoflare heating is consistent with these observations if the lower corona is not just heated, but continuously replenished by chromospheric material heated to coronal temperatures.

## Stellar Coronae

*Jürgen Schmitt*
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The last two decades have seen the emergence of a new field in stellar astrophysics: Stellar X-ray astronomy. With soft X-ray imagery X-ray emission was found from many thousands of solar-like stars. I will summarize the most important findings of X-ray surveys of late type stars and put those into the context of the solar-stellar connection. Similarities and difference between solar and stellar X-ray emission will be discussed. The results of eclipse observations to determine stellar structure will be reviewed, and recent results of X-ray spectroscopy (with Chandra and XMM-Newton) will be discussed mostly from the point of view of density diagnostics.

## Comparison of Empirical Models for Polar and Equatorial Coronal Holes

*M. P. Miralles et al.*
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A large equatorial coronal hole was observed with UVCS during 12 - 14 November 1999. Observations in H I Ly$\alpha$ and O VI 103.2 and 103.7 nm provided spectroscopic diagnostics of proton and $O^{5+}$ velocity distributions and outflow velocities. Values of electron density derived from the UVCS visible light channel will be presented. The resulting empirical model will be compared to an empirical model for a polar coronal hole observed near solar minimum. The several obvious differences in the two structures may be associated with the different magnetic field configurations and flux tube expansion factors.
(Co-authors: *S. R. Cranmer, A. V. Panasyuk, M. Romoli, R. Suleiman, and J. L. Kohl.*)

## A Spectroscopic Study of the Solar Corona from Norikura and SOHO data

*K.P. Raju et al.*
*Indian Institute of Astrophysics, India*

Co-authors: T. Sakurai/NAOJ, Japan, K.Ichimoto/NAOJ, Japan
We report the results from a spectroscopic study of the solar corona, wherein, we examine some of the current problems in the corona, such as the plume-interplume differences in coronal holes, coronal loops in active regions and wave propagation in the corona. The distribution of emission line intensities, Doppler velocities and line widths in the corona were obtained from the spectroscopic observations made in the coronal emission lines from Norikura Coronagraph. The coronal images in Fe IX,X 171 Å and Fe XII 195 Å from SOHO EIT were used to get the temperature map of the corona. Combining both, the nonthermal velocities in the coronal region are obtained without the usual assumption of a uniform ion temperature. Following results are obtained from the study. (1) The Doppler velocities show excess blue-shifts over red-shifts in coronal holes with differences in plume-interplume regions. (2) The nonthermal velocities show a pronounced difference between the coronal hole and closed-field regions which points to the important role of nonthermal broadening mechanism in the acceleration of fast solar wind. (3) The nonthermal velocities are larger by about 20 % at the interplume regions as compared to plumes. This supports the view that the interplume regions are the source regions of the fast solar wind. (4) The preliminary analysis of the time sequence data shows signatures of wave propagation in the corona.

## Nonlinear Spectral Dynamics and Energization of Space Plasmas by Kinetic Alfvén Waves

*M. Goossens et al.*
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Classic Alfvén waves (AWs) can be converted into kinetic Alfvén waves (KAWs) by phase mixing in inhomogeneous space plasmas, such as solar corona, solar wind and other astrophysical objects. Linear phase mixing on its own appears not to be able to provoke significant kinetic effects in AWs propagating initially along magnetic field. Here we present mechanisms that are more efficient once phase mixing has created the perpendicular wavenumber in a small-amplitude AW. In the framework of two-fluid MHD we show that the initial AW can nonlinearly couple its energy to other, secondary AWs, resulting in nonlinear spectral transfer of wave energy. The nonlinear generation of secondary waves can initiate a turbulent cascade of energy towards smaller scales and higher frequencies, where kinetic dissipation mechanisms of KAWs due to Landau and cyclotron damping are of a prime importance.

The recent SOHO observations of the solar corona and solar wind, implying dissipation of small-scale and/or high-frequency Alfvén waves, are discussed in the light of our theoretical results. We suggest that the spectral dynamics and consequent dissipation of KAWs introduced by the combined action of phase mixing and nonlinear interaction is a widespread phenomenon, important for astrophysical plasmas.

Co-author: *Yu. Voitenko (MAO, Kyiv, Ukraine)*

## Coronal Heating and Solar Wind Acceleration

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A new scenario on the coronal heating and the accelerations of the solar wind is presented. This is based on the DC injection of the energy flux as the twisting magnetic field coming from faculae. The twist in the corona will produce charge separation and consequently electric field parallel to the magnetic field. Accelerated beam electrons due to the latter electric field will be stopped by classical collisions with ambient electrons and ions. The beam electrons do not create electric currents due to the back streaming bulk electrons so that the proposed heating is not the Joule heating, nor anomalous Joule heating, but a co-spatial frictional heating. The heating rate is $H_{beam} = m_e n_b V_b^2 \nu \approx$ a few times $10^{-4}$ erg $cm^{-3}$ $s^{-1}$. Here $m_e$ is the electron mass, $n_b$ number density of the beam electrons (roughly $10^{-3}$ of the electron density), $V_b$ velocity of the beam electrons of typically 2 - 3 times electron thermal velocity, and $\nu$ collision frequency of beams of 14 $s^{-1}$. This heating rate is sufficient to heat the closed loop and to accelerate the solar wind plasma flow in an open field. This heating rate succesfully reproduces the observed scaling laws in both quiet and active regions. Though the radii of the coronal loop are not a critical parameter unlike in the Joule heating, they are in the range between 1000 km (coming from the 0.3" faculae), and 10 km (coming from the critical radius inside a facula between frozen and non-frozen).

Since the heating is larger in the lower corona, closed loops are expected to be thermally unstable, and to repeat evaporation and draining down after cooling like recurrent small thermal flares. Namely, in the closed loop, the coronal heating is excessive. On the other hand in the open field, this excessive heating produces evaporative plasma upflows. The heating will remain appreciable up to several solar radii. We find that the terminal velocity of the wind is prefixed deep in the corona and not by interplanetary conditions. Since we identified the dissipative process of the twisting, $H_{beam}$, to create a high speed wind becomes basically possible.

**Highlight results from Ulysses**

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Launched in October 1990, the ESA-NASA Ulysses mission has conducted the very first survey of the heliosphere within 5 AU of the Sun over the full range of heliolatitudes. With polar passes taking place in 1994 and 1995, the timing of the mission has enabled Ulysses to characterise the global structure of the heliosphere at solar minimum, when the corona adopts its simplest configuration. The most important findings to date include a confirmation of the uniform nature of the high-speed (∼750 km/s) solar wind flow from the polar coronal holes, filling two-thirds of the volume of the inner heliosphere; the sharp boundary, existing from the chromosphere through the corona, between fast and slow solar wind streams; the latitude independence of the radial component of the heliospheric magnetic field; the lower-than-expected latitude gradient of galactic and anomalous cosmic rays; the continued existence of recurrent increases in the flux of low-energy ions and electrons up to the highest latitudes. In this r

**Solar Wind Compositional Variations**

*A.B. Galvin et al.*
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Recent in-situ measurements of the composition of the solar wind are providing valuable and often unique new information on origins and processes in the Sun. We review some of the more interesting results and their implications, with emphasis on observations made by the CELIAS collaboration on SOHO.

Fractionation processes present in the upper chromosphere create significant differences in coronal and solar wind elemental abundances relative to photospheric abundances. The differences are not uniform: the effect is smaller in coronal hole-associated "fast" solar wind than in "slow" solar wind. Unusual compositional signatures have been observed in interplanetary coronal mass ejections.

Solar wind isotope studies beyond the light noble gases are now available from high mass resolution sensors. The solar wind reflects the isotopic composition of the outer convection zone of the Sun – the least biased sample remaining of the original interstellar matter that formed the solar nebula 4.6 billion years ago. For volatile elements, solar particles provide the most direct determination of solar abundances. For refractory elements, which can also be reliably inferred from meteoritic samples, deviations observed in the solar wind provide upper limits on the more subtle fractionation processes in the OCZ and solar atmosphere.

**Magnetic cloud as two nested flux ropes**

*M. Vandas et al.*
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Some examples of magnetic clouds will be analyzed and it will be shown that measurements of magnetic field and solar wind plasma are consistent with an interpretation that these magnetic clouds consist of two nested flux ropes. The inner flux rope has a strong magnetic field and low plasma density. The outer flux rope has the same chirality but opposite polarity.

(Co-author: A. Geranios, Athens University, Greece.)

**Wave induced synergetic electron acceleration in inhomogeneous solar plasmas**

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Suprathermal electron populations are generated efficiently in uniform space plasmas by resonant Landau interaction with broadband Alfvén wave spectra. Based on a simulation of the particle acceleration in response to the wave energy input within the Fokker-Planck formalism, details of the time evolution of the velocity space distribution towards commonly observed solar wind power law spectra are discussed. Furthermore, it is shown that the diffusion properties and consequently the particle energization change significantly in astrophysical environments with magnetic field and density gradients, since synergetic effects become dominant. Electrons are accelerated resonantly out of the bulk of the distribution such that they interact again with a wave packet of higher phase velocity, leading to a multi-stage energization. Hence, a unique acceleration mechanism can be achieved without postulating pre-acceleration by ad hoc mechanisms.

Depending on the density and magnetic field profile, significant enhancement of energetic particles as well as stagnation in a saturated stage of suprathermal, non-Maxwellian velocity space distributions is possible. The importance of synergetic acceleration in complex solar flare structures and for solar wind heating mechanisms is discussed in relation to spacecraft observations.

**Particle Acceleration on the Sun and in the Heliosphere**

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In impulsive solar energetic particle (SEP) events, relativistic protons and electrons often reach maximum intensity within a few minutes of event onset. Their acceleration must therefore have been completed within a few solar radii of the Sun. On the other hand, non-relativistic ions and electrons are observed to be accelerated throughout interplanetary space in association with shocks bounding either coronal mass ejections (CMEs) or corotating magnetic interaction regions (CIRs). Given the large distances and transit times from the acceleration sites to the spacecraft, we need to understand the mechanisms controlling the propagation of energetic particles throughout the heliosphere before we can analyze the acceleration process. The most important ones are field-aligned transport and energy loss. Field-aligned transport results from weak pitch-angle scattering combined with the focussing effect of the outwardly decreasing interplanetary magnetic field (IMF). A species-independent fractional momentum loss rate in this weak-scattering limit is produced by the magnetic field gradient and curvature drifts of the particles having a component anti-parallel to the electric field in the solar wind. Recent results on particle acceleration have been obtained by comparing observations near Earth (IMP8 and ACE) with those from matched detectors on Ulysses ($\sim$5 AU and up to $\pm 80^\circ$ heliolatitude) and Voyagers 1 and 2 ($\sim$60 AU and $\pm 30^\circ$ heliolatitude).

**Particle Acceleration in Collisionless Magnetic Reconnection**

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Magnetic reconnection is a process of fundamental importance in the solar atmosphere, particularly in flares and in coronal heating. The acceleration of charged particles is a key diagnostic of reconnection, and we investigate this process in the framework of collisionless reconnection, relevant to hot tenuous plasmas where the length scale of the reconnection region is less than the particle mean free paths. We consider a steady reconnection scenario, with a two dimensional X-point magnetic field geometry, and an inductive electric field generating an inflow of particles. The aim is to investigate the effect of adding a uniform field component transverse to the plane of the X-point field. Test particles trajectories are studied, and the energy spectra of the accelerated particles leaving the reconnection site are determined. The interesting parameter regime is when there is both significant direct acceleration, due to the component of the magnetic field parallel to the driving electric field, and parallel acceleration generated through the interaction of the electric drift motion with the inhomogeneous magnetic field.

Co-author: G.V. Vekstein

**Collisionless reconnection in the structure and dynamics of active regions**

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New theoretical interpretations are discussed of the *Yohkoh* data on the site and mechanism of magnetic energy transformation into thermal and kinetic energies of superhot plasmas and accelerated particles. We develop a model that explains observed properties of reconnection in active regions and in flares. The transition from slow reconnection to fast one is demonstrated by numerical solutions of the problem taking into account anomalous resistivity and anomalous heat conduction. The model also makes intelligible the observed decrease (increase) of the separation between the double-footpoint hard X-ray sources in the more impulsive (less impulsive) flares. An accumulation of the reconnected magnetic flux can explain the observed ascent motion of the coronal source of hard X rays in flares. We demonstrate some features of electron and ion acceleration in collapsing magnetic traps.

**Heliospheric Signatures of Coronal Mass Ejections**

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*Observatoire Meudon, France*

We review the role of Coronal Mass Ejections (CMEs) in the development of solar activity in the interplanetary space and particularly in relation to space weather. CMEs, just as the solar flares, represent a major release of energy from the Sun. We will discuss a few of the outstanding issues regarding the genesis and evolution of CMEs throughout the heliosphere.

**Heliospheric magnetic field configuration and its coronal sources**

*T. H. Zurbuchen*
*University of Michigan, USA*

The heliospheric magnetic field configuration is largely determined in the solar atmosphere. The interplanetary magnetic field is therefore intimately linked with the coronal structure and evolution during the solar cycle. Traditionally, this interdependence has been studied using time-stationary models which often manage to predict the approximate large scale properties of the magnetic field configuration.

However, the solar source is clearly time-dependent on many scales, for example, due to differential rotation effects. Fisk in 1996 has pointed out that such effects will lead to footpoint motions which significantly alter the heliospheric magnetic field configuration on large scale. We will review this work and address the importance of footpoint motion during the solar cycle. We will point out that these effects may be essential for the reconfiguration of the heliospheric magnetic field during solar activity maximum.

**Components of the Local Interstellar Medium**

*J.L. Linsky et al.*
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(Co-authors: S. Redfield & B.E. Wood/JILA.) HST, EUVE, and optical Ca II spectra are providing the critical velocity and column density data needed to identify individual structures (clouds) of warm gas in the local ISM near the Sun. We determine the shape and physical properties of the Local Interstellar Cloud (LIC) from 43 lines of sight. The Sun is located very close to the edge of and will soon leave the LIC. Analysis of UV and optical spectra for another 20 lines of sight permit us to determine preliminary sizes and properties of other clouds located within about 50 pc of the Sun. We will show new results for the G, NGP, SGP, and other clouds. These nearby clouds appear to have the same D/H ratio as the LIC, but they have different velocity vectors, temperatures, and metal depletions. We will also discuss their ionization equilibria and relation to the Scorpio-Centaurus Association and the Local Bubble.

**The Local Interstellar Medium**

*Rosine Lallement*
*Service d' Aéronomie, France*

Constraints on the circumsolar interstellar medium and the confinement of the heliosphere can be inferred from the combination of SOHO and Ulysses data, in conjunction with astronomical observations (essentially nearby star spectroscopy with the EUVE, the HST, and from ground). I will review the recent results and discuss open questions.